Rechnitzer-Cunningham Annual Lecture

Declines in cardiovascular function with aging: Does this need to be the case?

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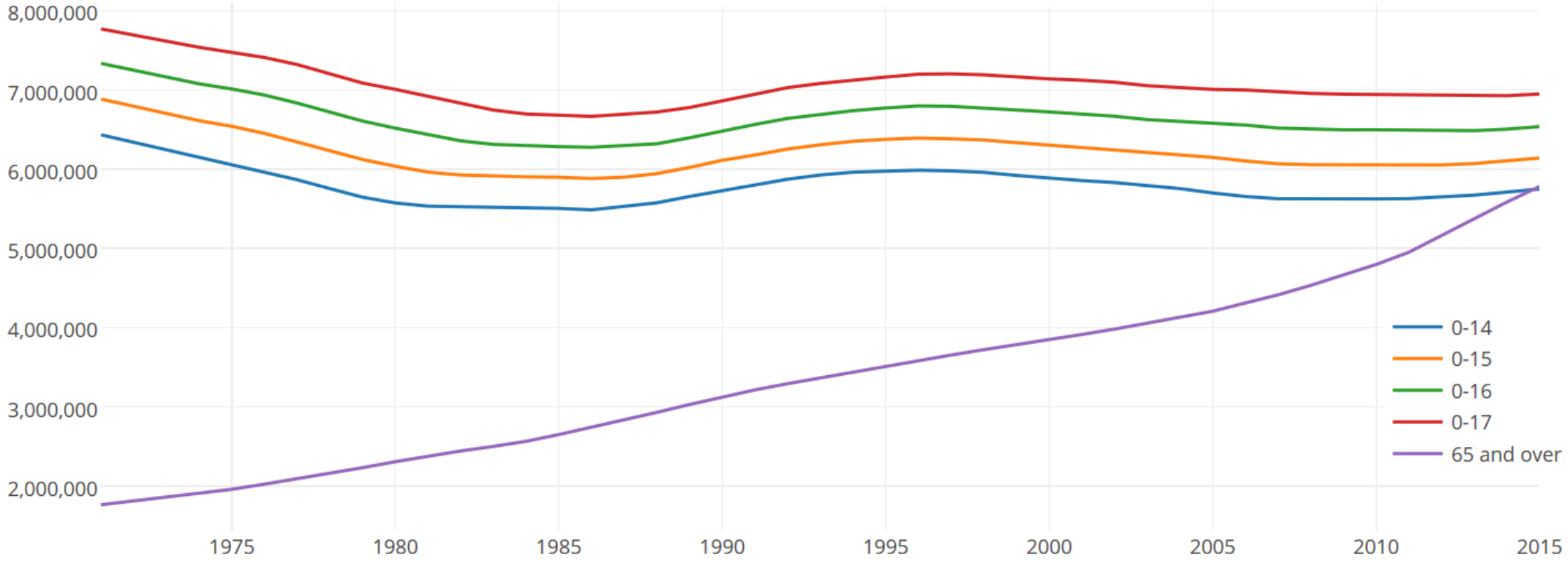
Before we start…

<u>This presentation</u>:

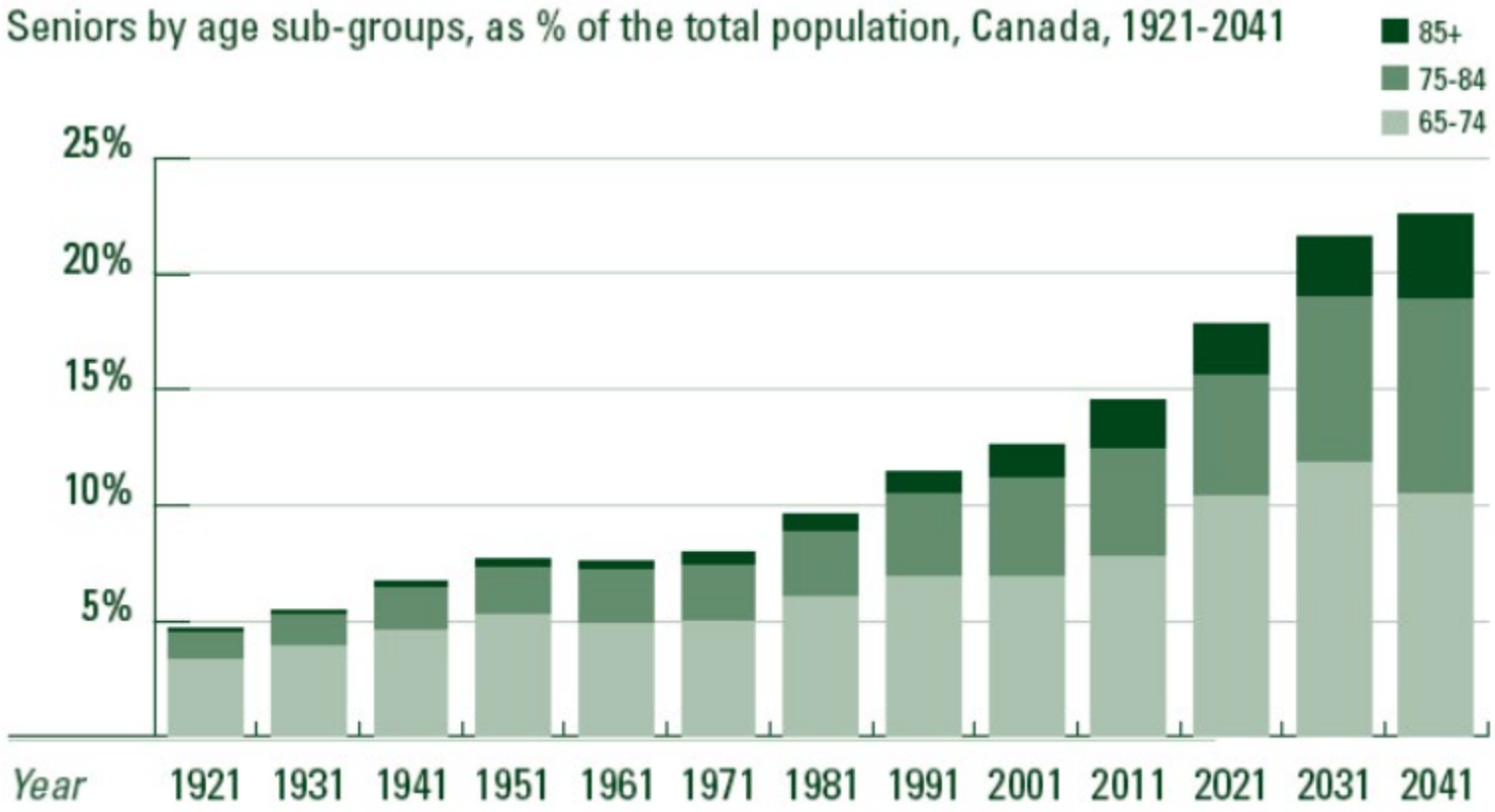
- Focusses on some specific CV adjustments/adaptations to acute and chronic exercise interventions.
- Discusses data on “healthy aging”.
- Discusses training adaptations for people exercising ~3 x week.

Why aging and exercise?

More seniors than kids for the first time ever



Seniors by age sub-groups as a % of total population in Canada



Lindsay, Colin. *A portrait of seniors in Canada.* 3rd ed.
Cat. no. 89-519-XPE. Ottawa: Statistics Canada, 1999.

Is being older a problem?

NO

…but there are some functional limitations associated with aging

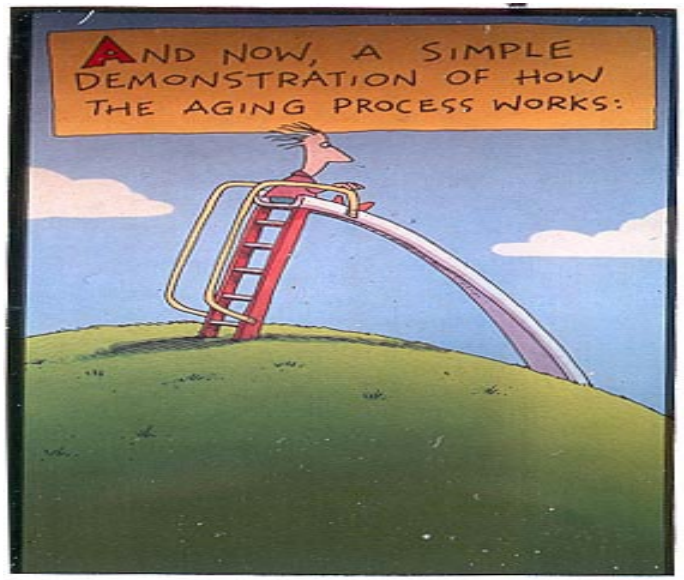
Why cardiovascular function and aging?

- CV disease is a leading cause of mortality and morbidity in the developed countries
- CV disease is more prevalent in the elderly
- Limitations in CV function ⇨ decline in function and loss of independence

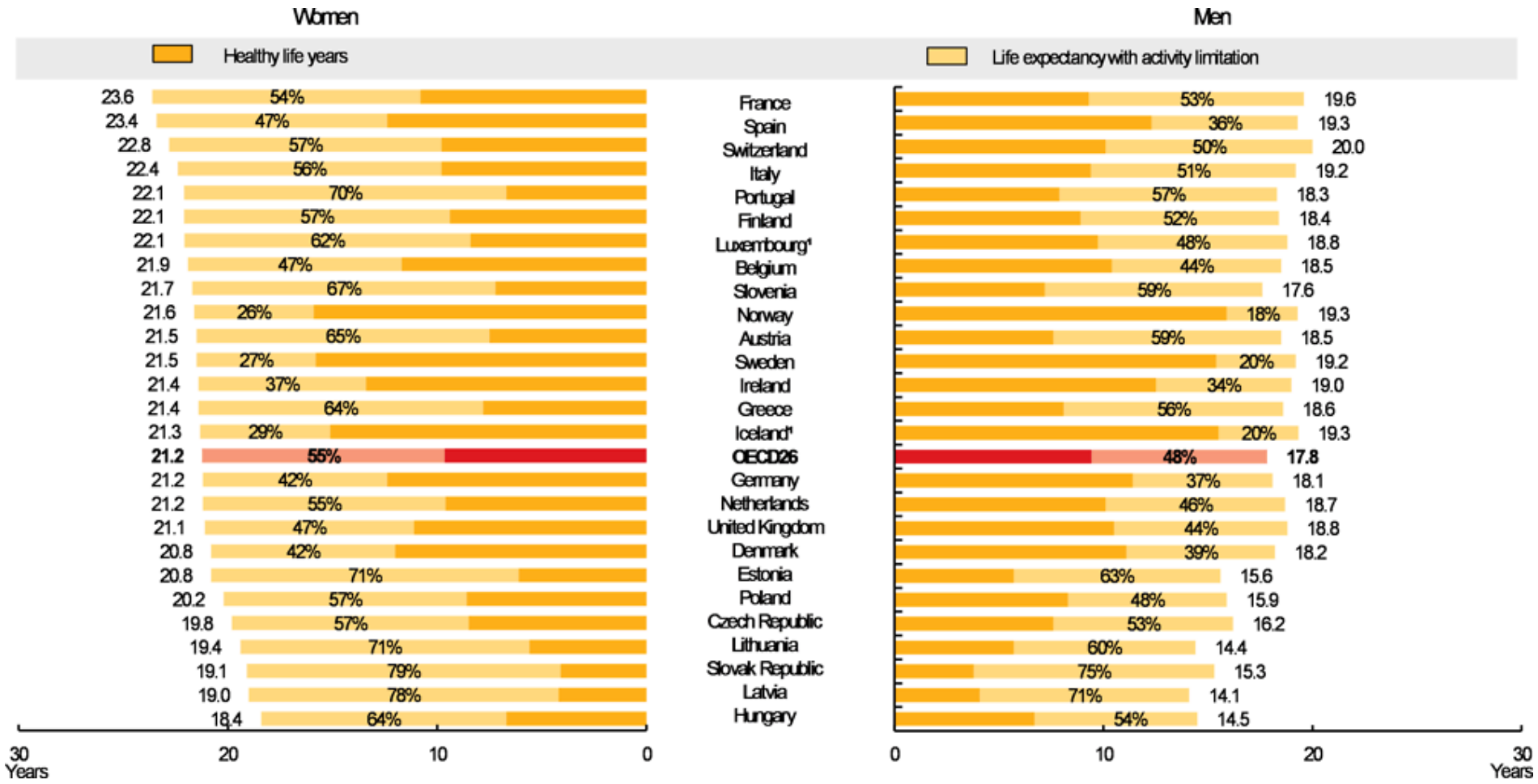
- **Life expectancy exceeding ability to maintain function**

(e.g. VO_{2max} < 20-25 $mL \cdot kg^{-1} \cdot min^{-1}$)

- Sustainability of health care?
  - Older adult health care 4 X cost per capita

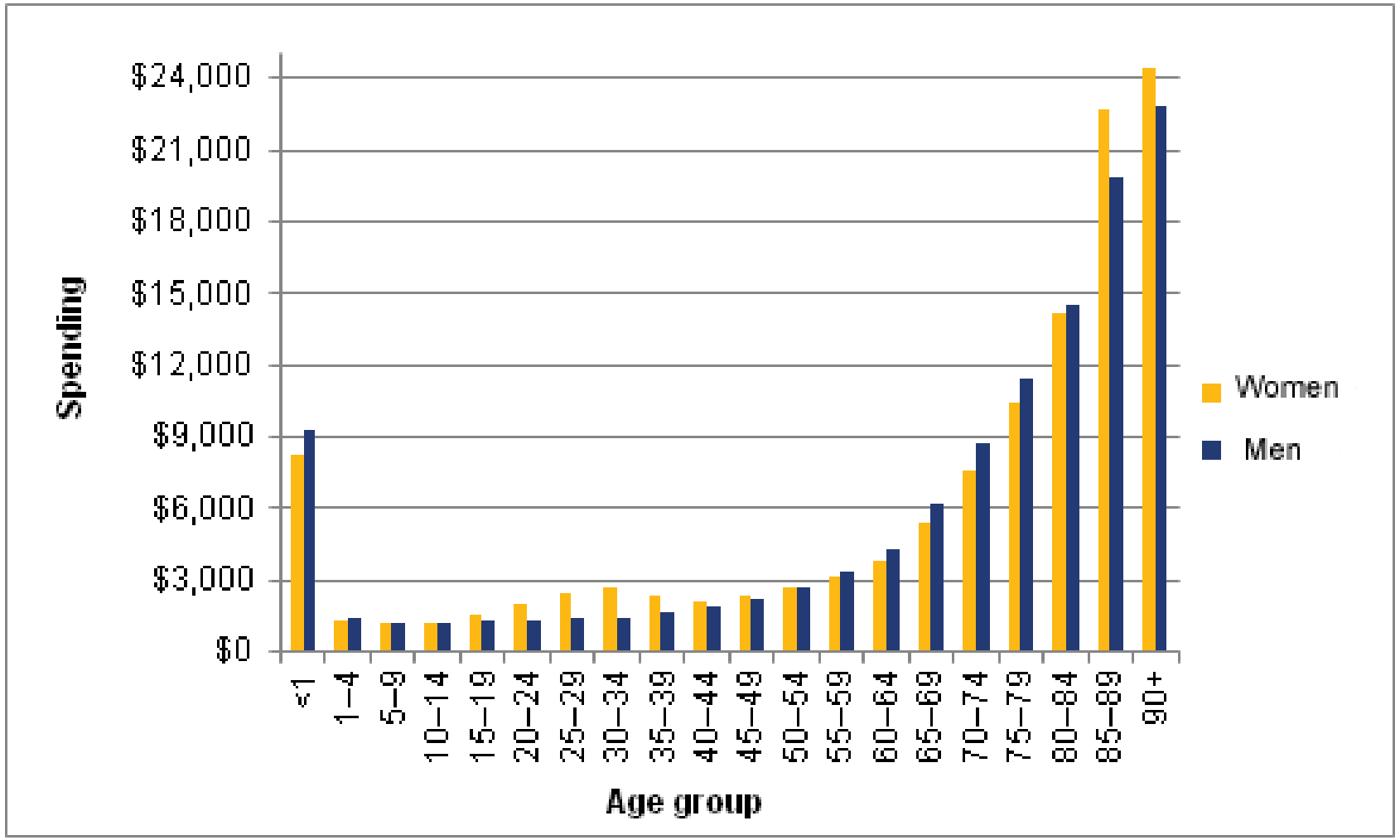


Life expectancy and healthy life years at age 65



Source: Eurostat Database

Public Health Care Spending per Person per Age Group



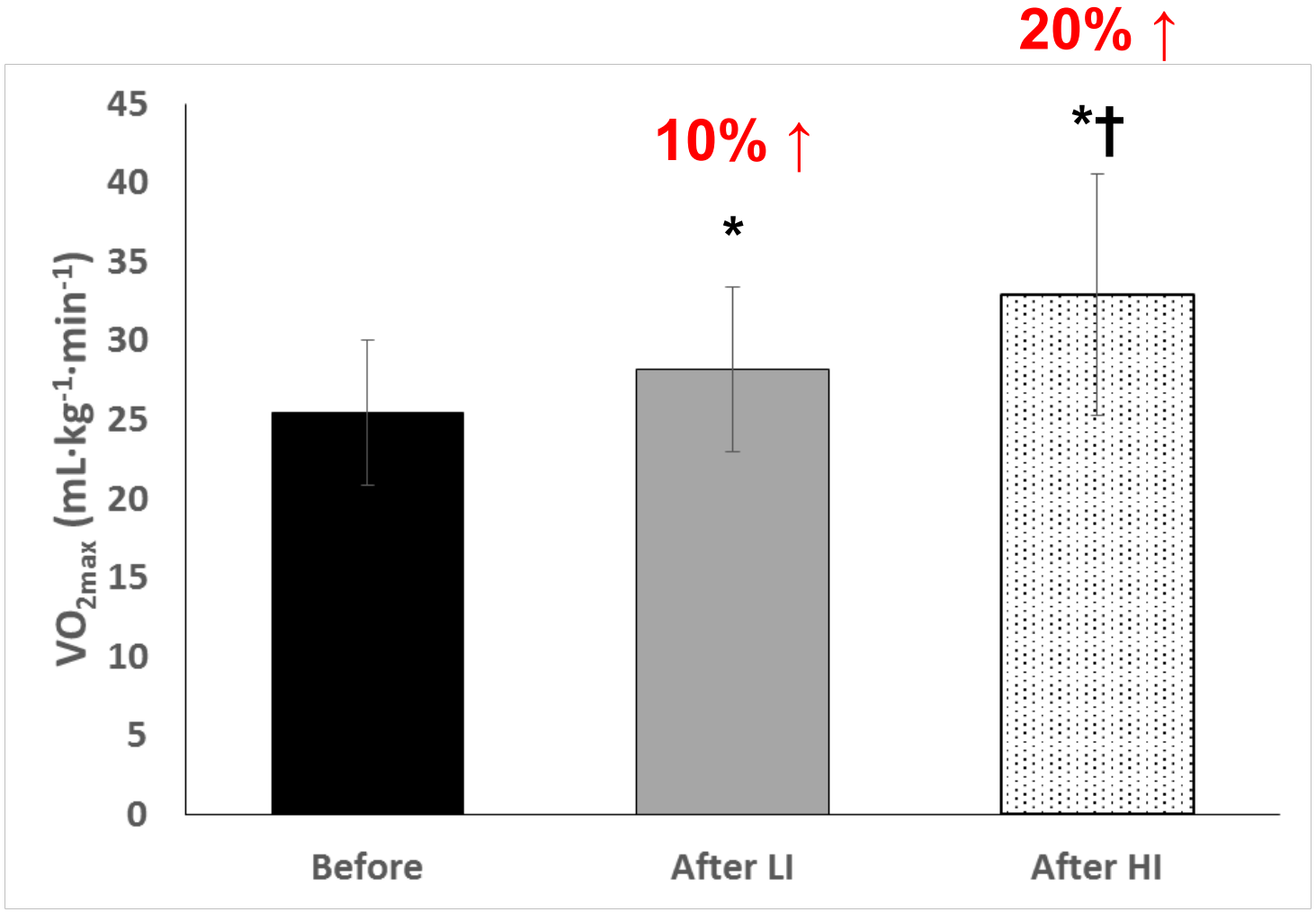
Can we improve Cardiovascular Fitness and Function in the Elderly with Exercise Training?

Some past studies

Exercise might kill you!!!

- Bassey et al., J. Gerontology (1978): “Vague fears that too much exercise will precipitate injury, catastrophic exhaustion, or overt illness bedevil the situation and have fostered disapproval of all but the mildest exertion.”

Endurance training in older populations

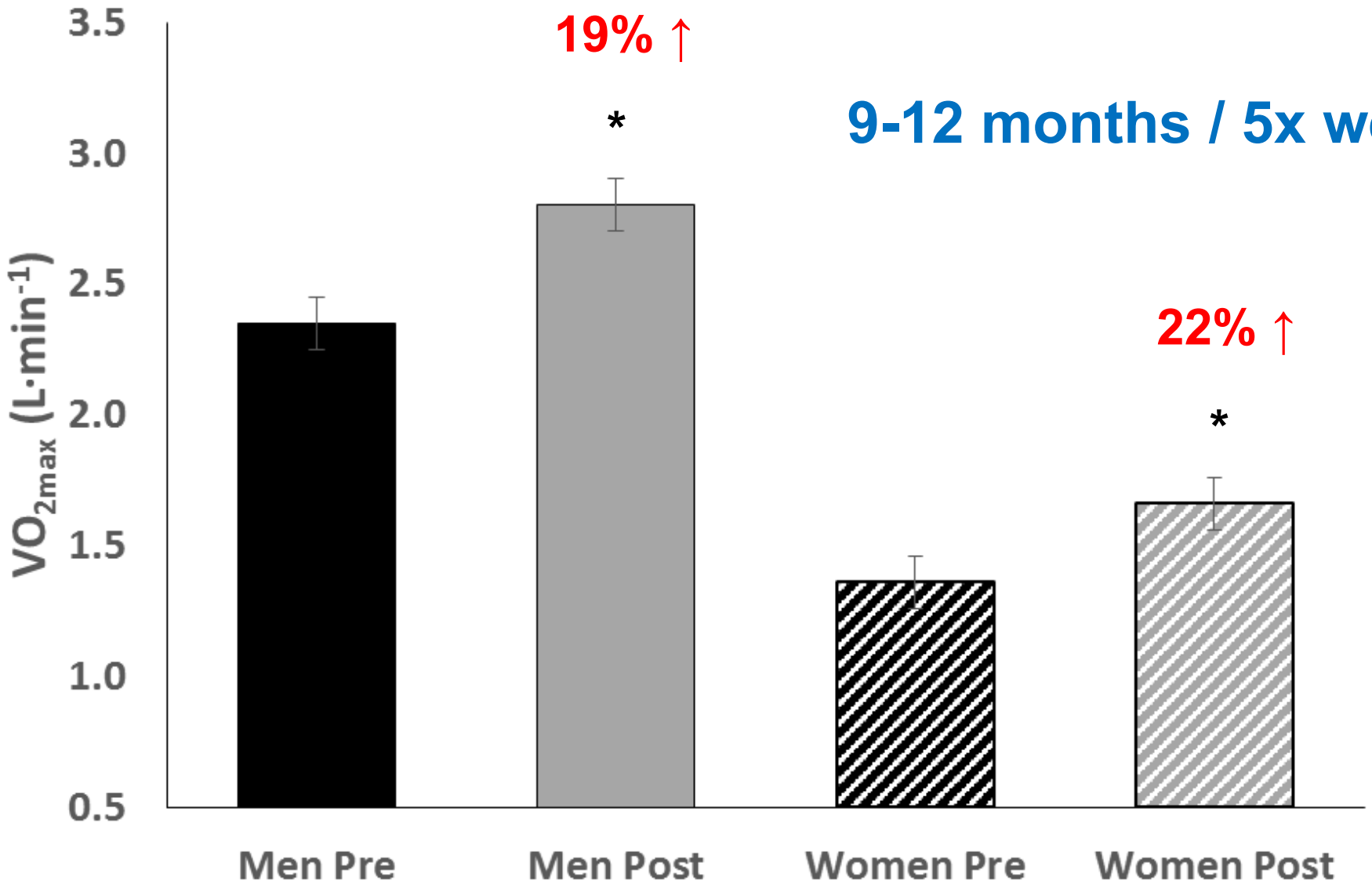


Low Intensity: 6 months at 55% HRR

High Intensity: 6 months at 75% HRR

n= 11 (7 men – 4 women)

Seals et al., J Appl Physiol 1984



9-12 months / 5x week / 70-80% HR_{max}

Spina et al., J Appl Physiol 1993

Study design

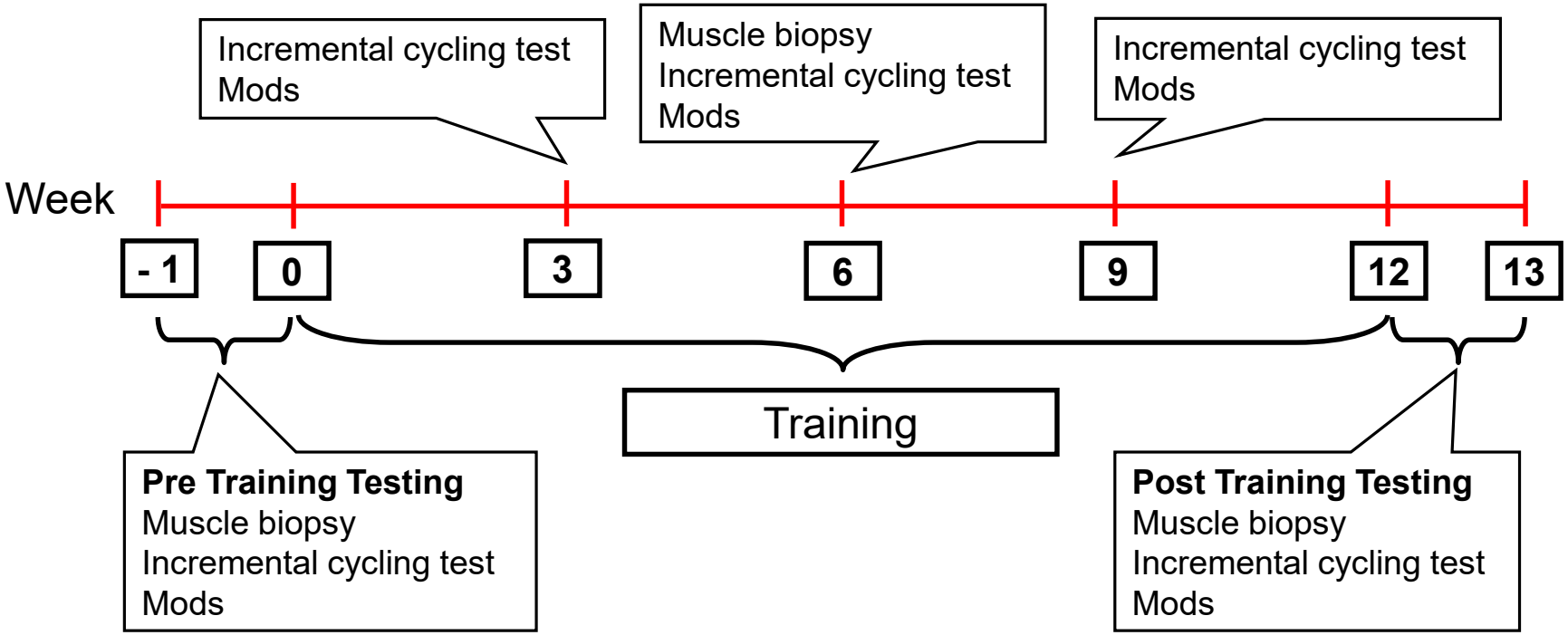
14 older adults
- 6 females (69 yr)
- 8 males (68 yr)

16 young adults
- 8 females (25 yr)
- 8 males (23 yr)

Continuous Training

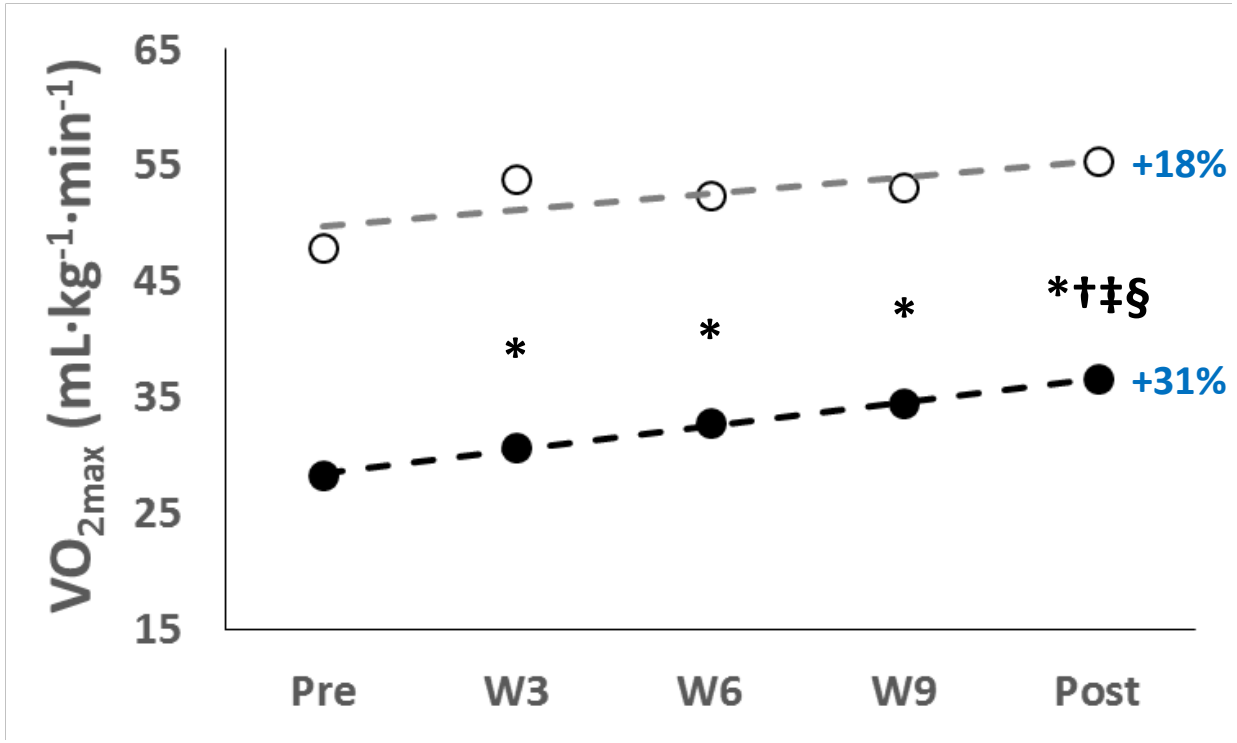
3 x wk, 45 min @ 70% VO_{2max}

Training intensity adjusted every 3 wk



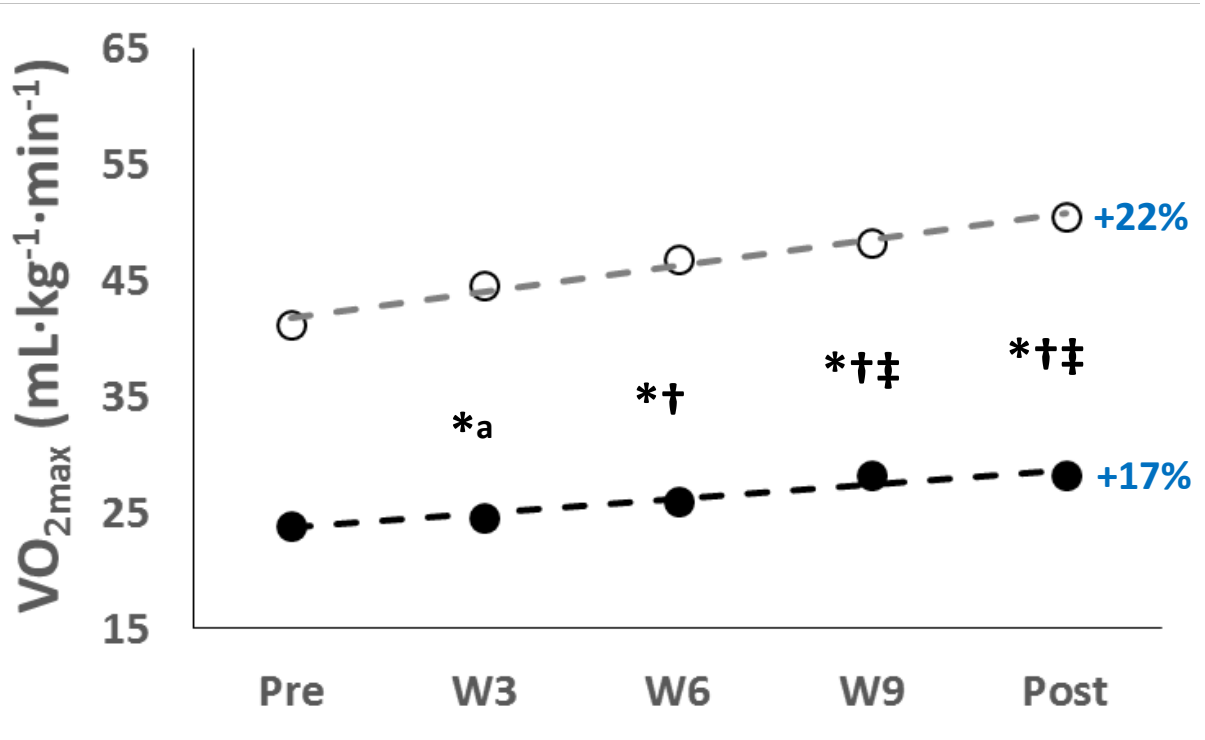
Results: Cardiovascular Fitness

Males



Murias et al., J Appl Physiol 2010

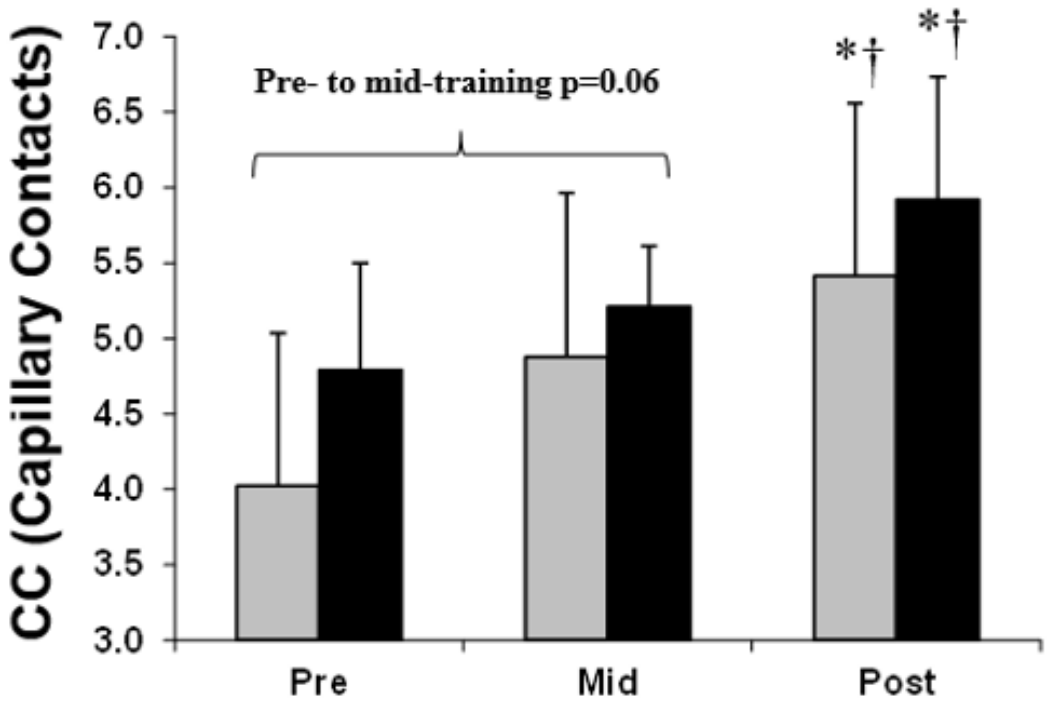
Females

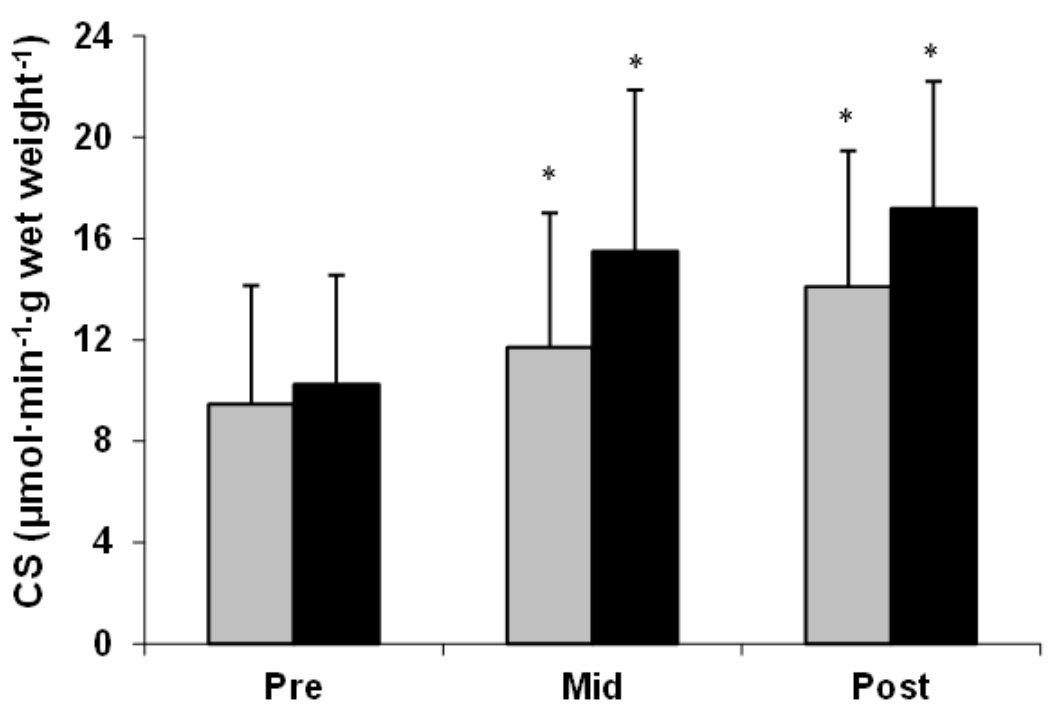


Murias et al., Med Sci Sports Exerc 2010

A 4+ mL·kg^{-1}·min^{-1} increase in VO_{2max} represents > than 50% reduction in the odd ratio of becoming dependent

Capillarization and CS activity



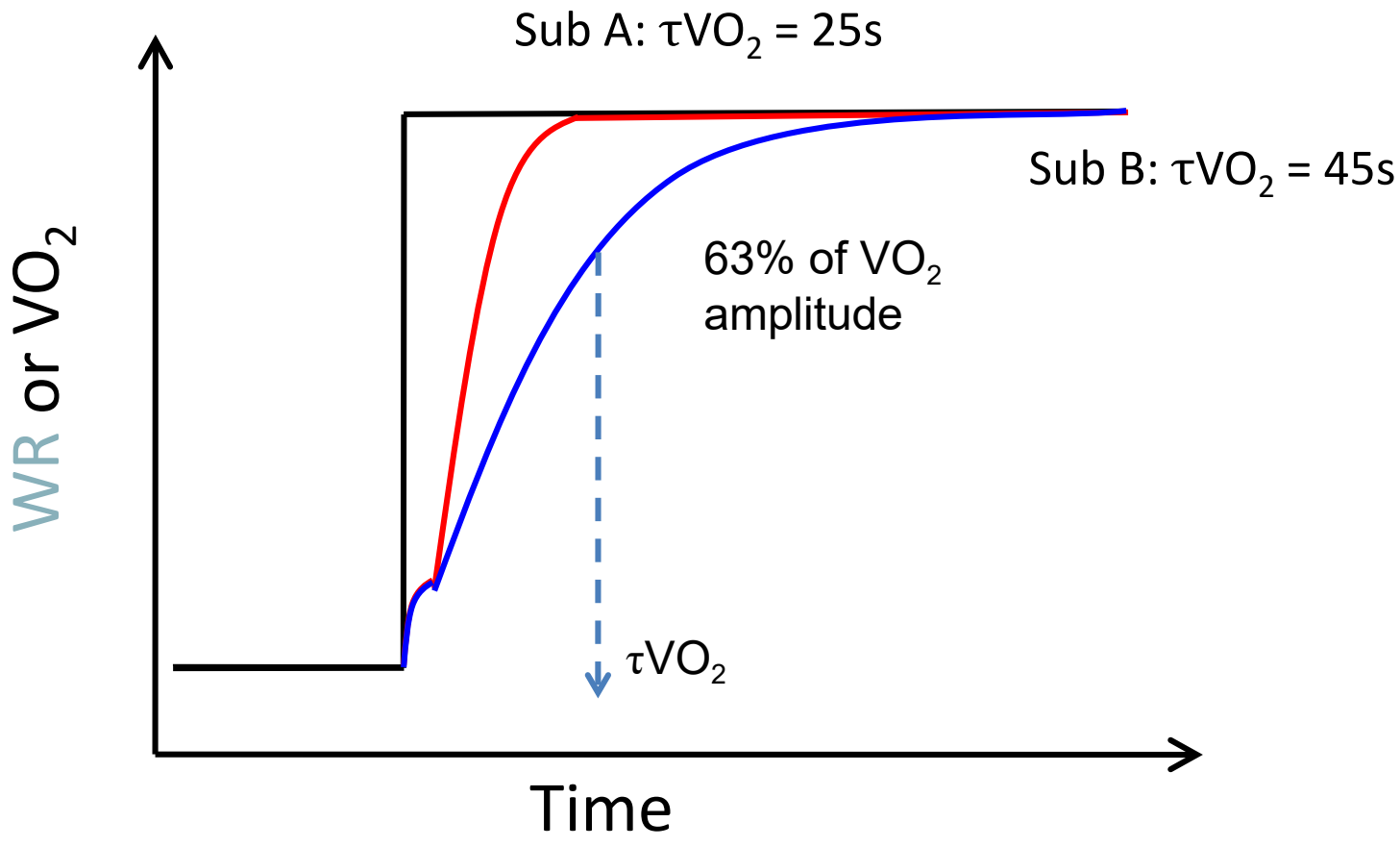


Older

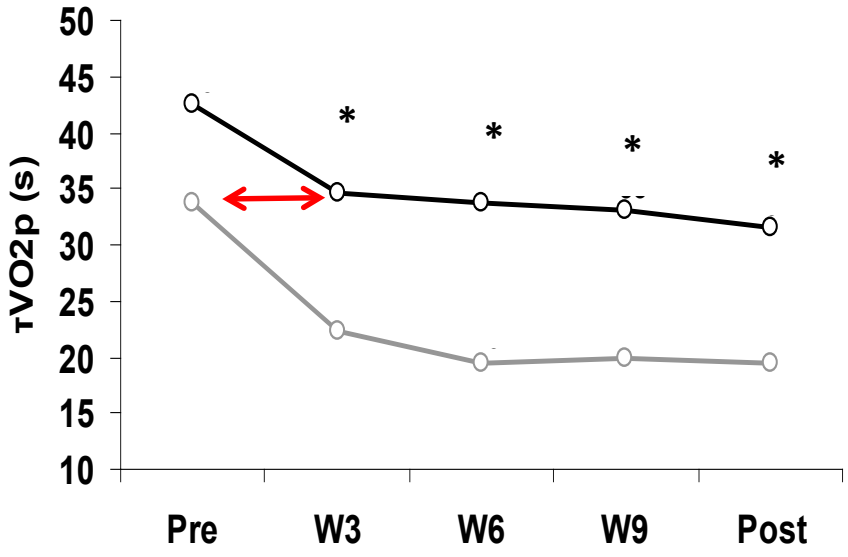
Young

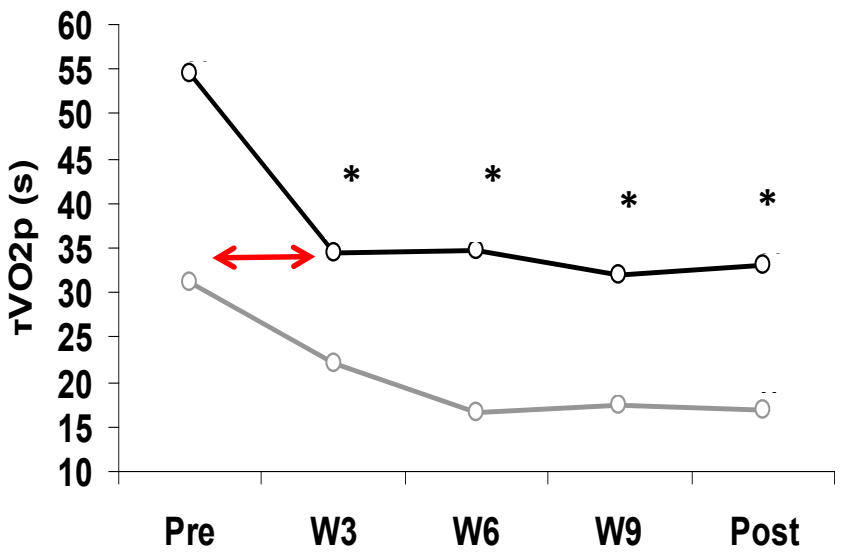
Murias et al., J Geront 2011

VO_2 kinetics: What is it?



Changes in τVO_{2p} in response to endurance training





Murias et al., J Appl Physiol 2010

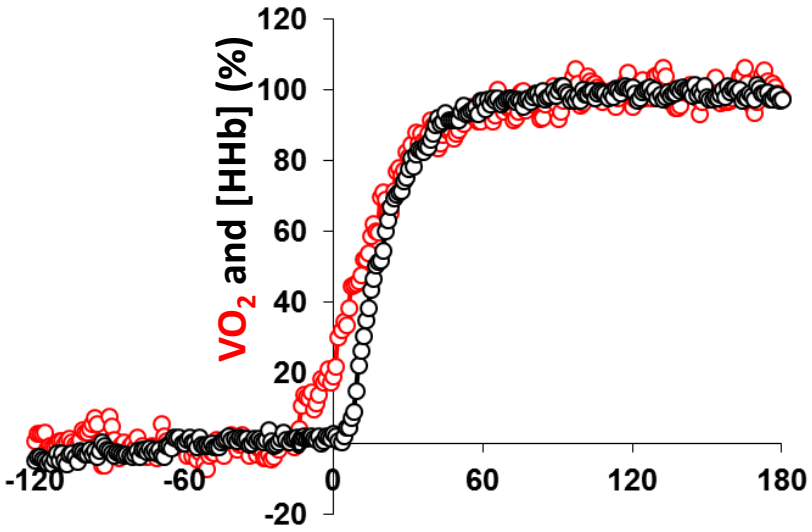
Young

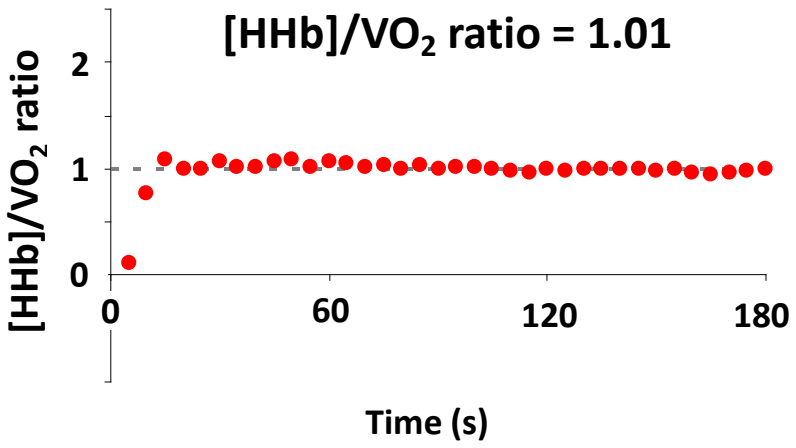
Older

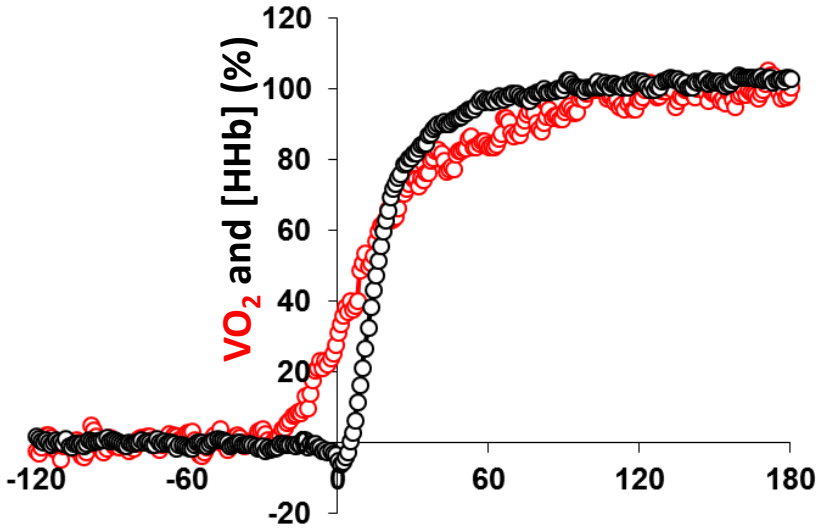
Murias et al., Eur J Appl Physiol 2011

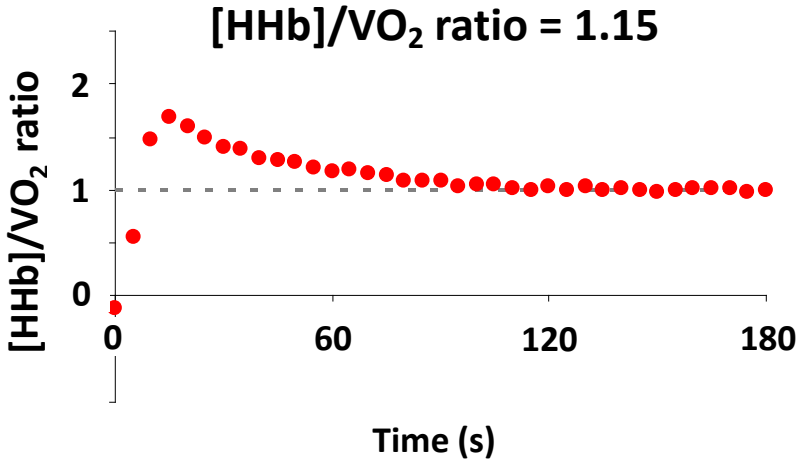
Changes occurred within the first 3 weeks of training regardless of sex and age

Experimental model: Integrating the VO_2 and [HHb] signals

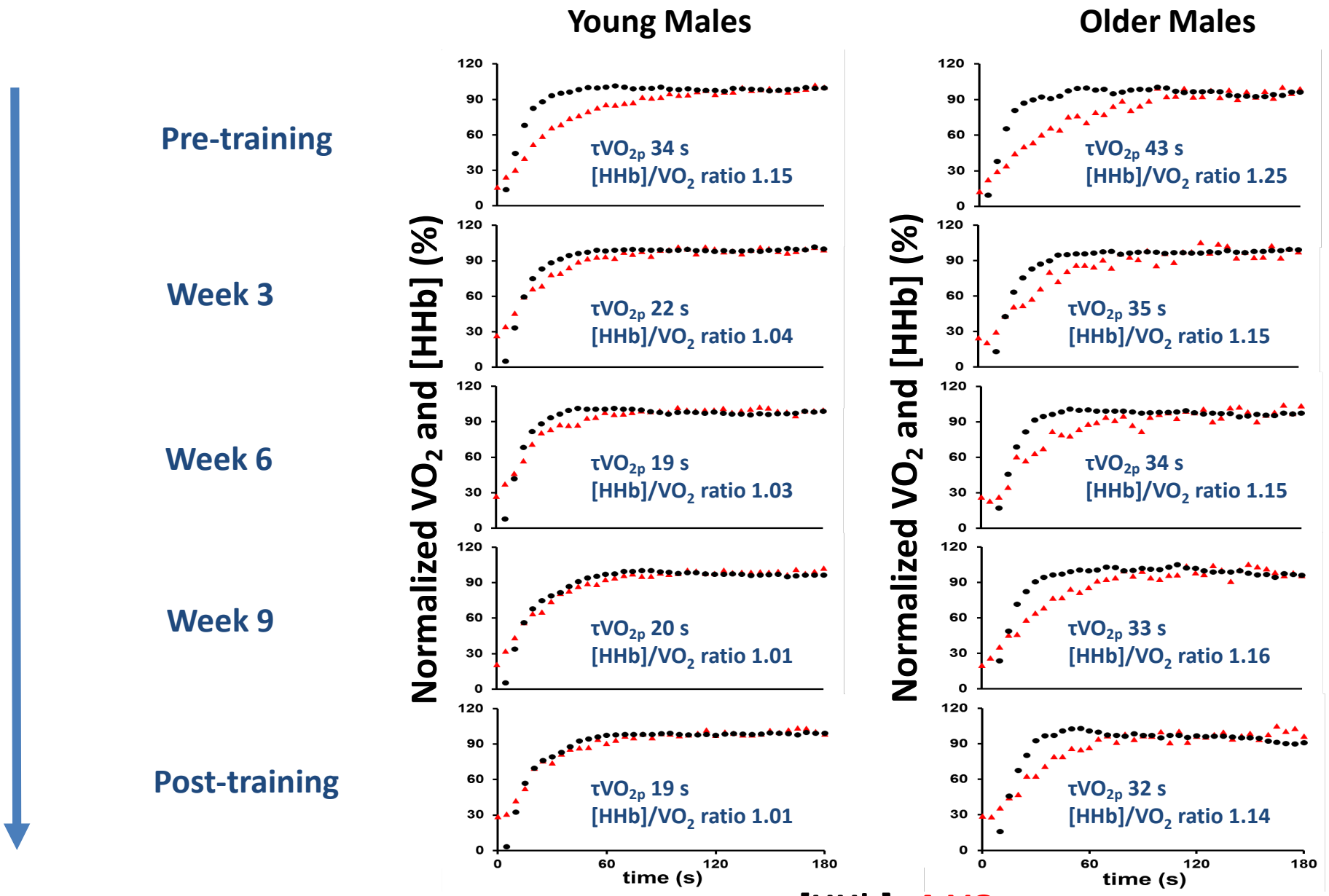








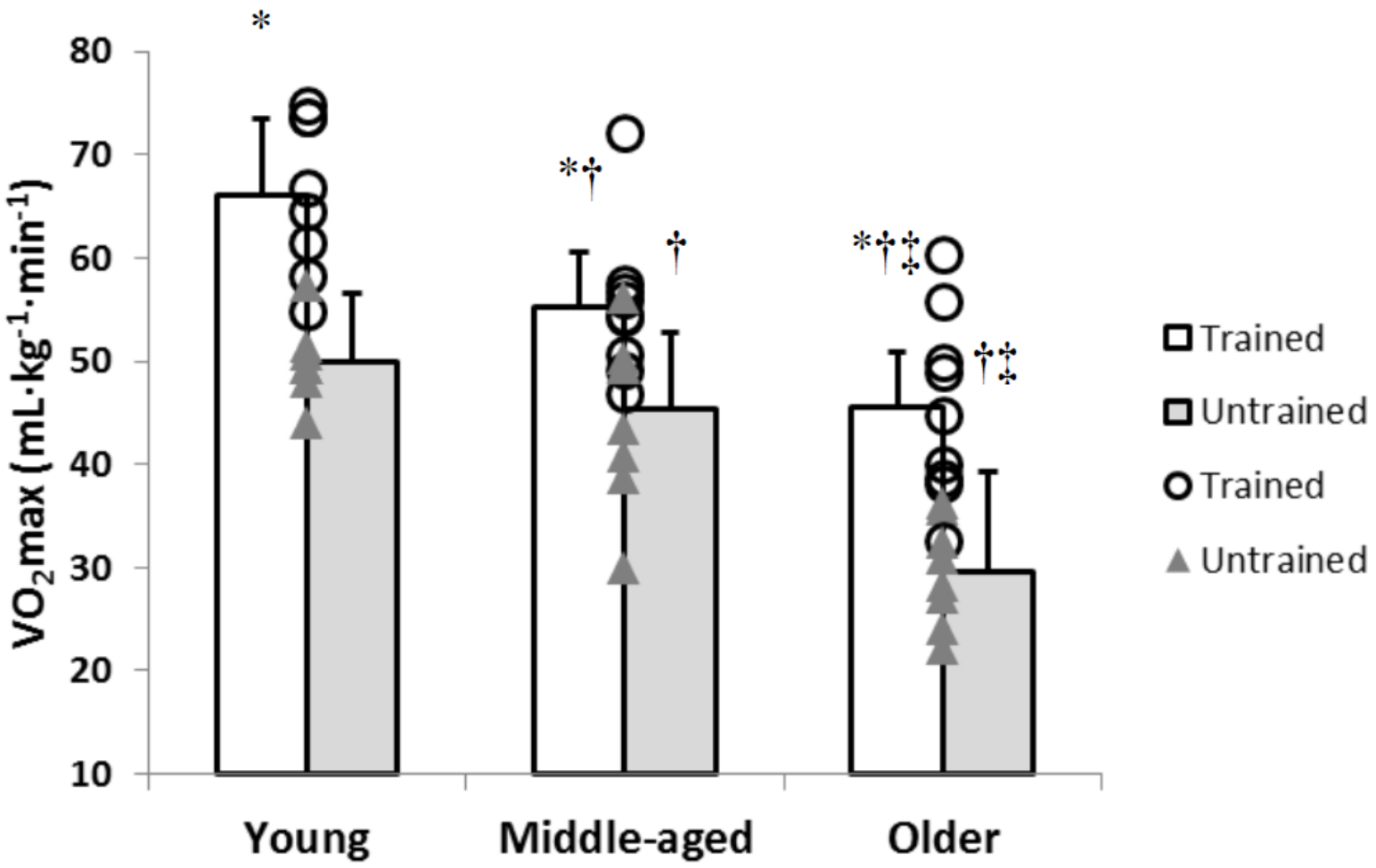
Rate of adjustment for VO_2 and [HHb] in response to endurance training



○ [HHb] Δ VO_{2p}

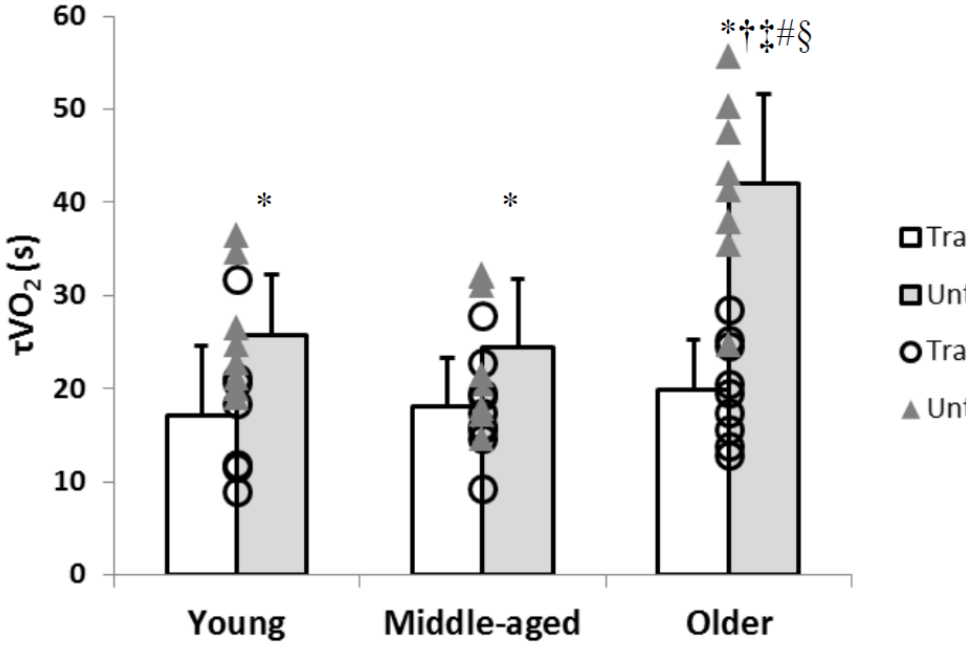
Murias et al., J Appl Physiol 2010

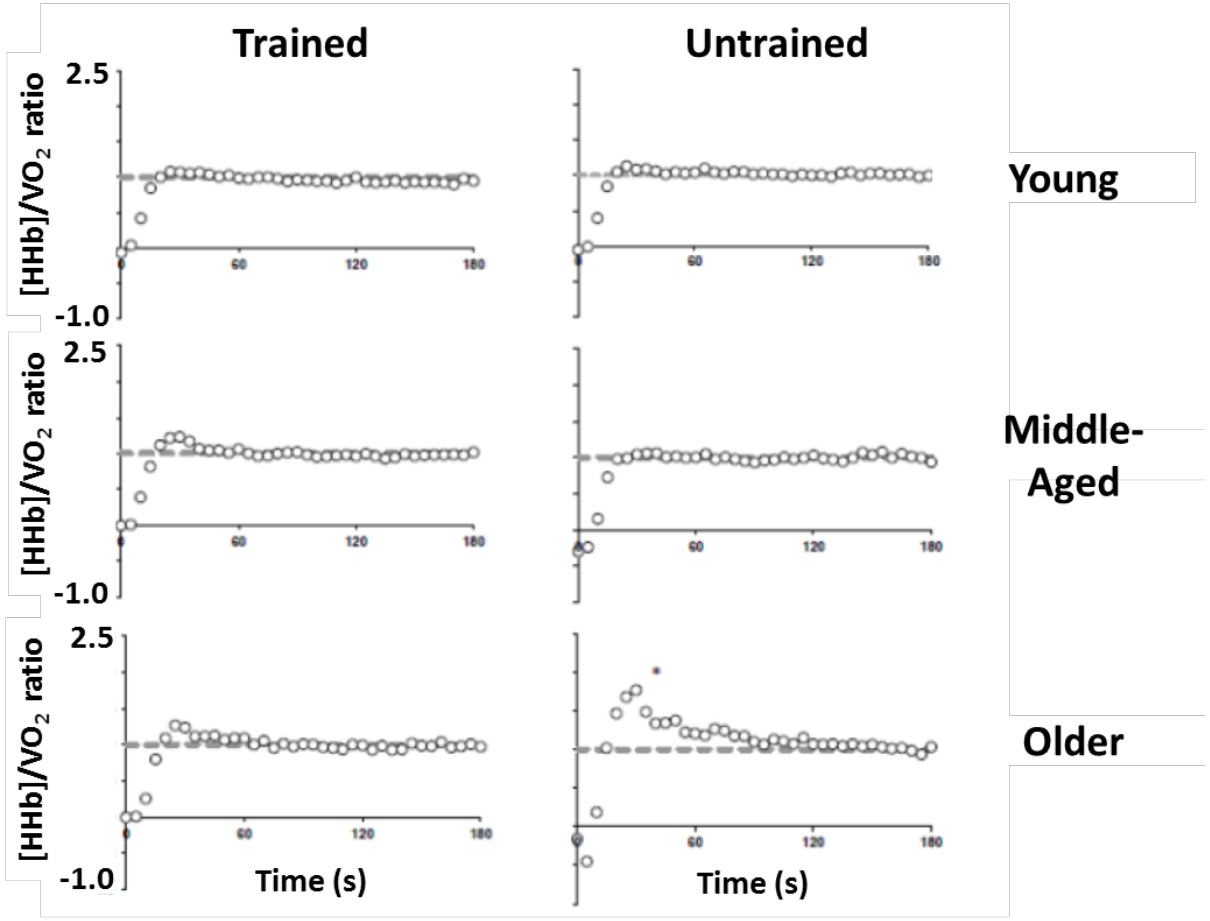
Effects of aging and training status



Grey et al., Med Sci Sports Exerc 2015

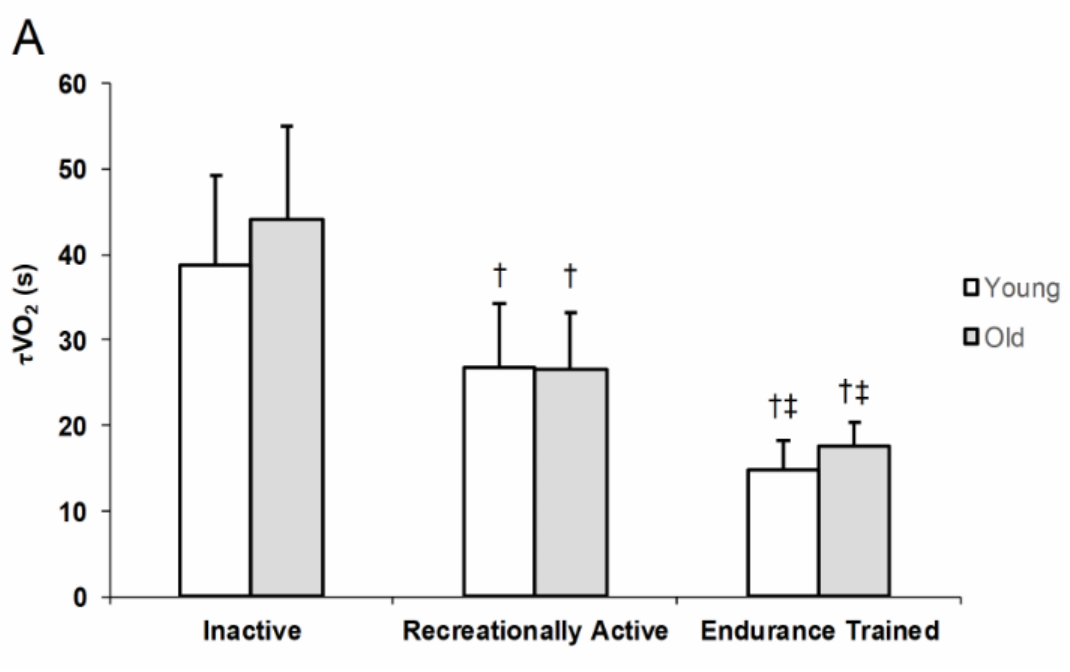
Effects of aging and training status

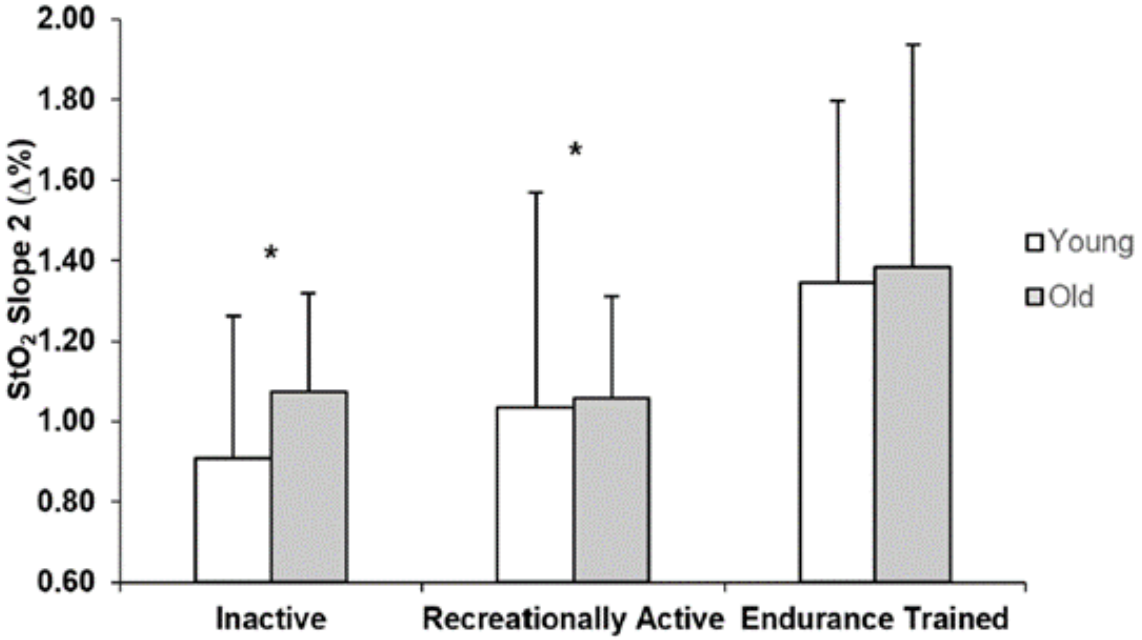




Grey et al., Med Sci Sports Exerc 2015

Effects of aging and training status

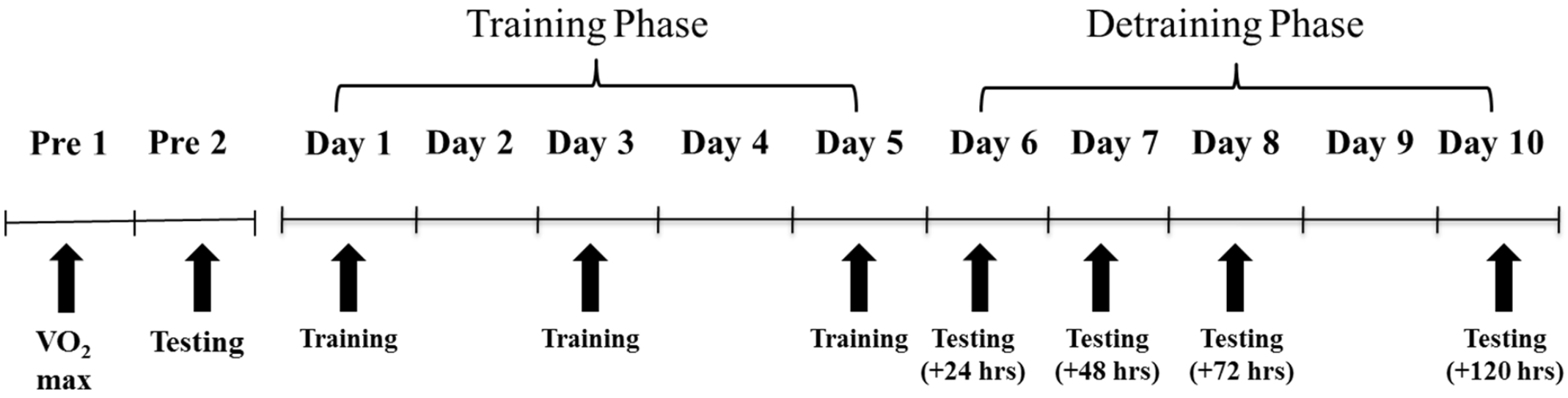




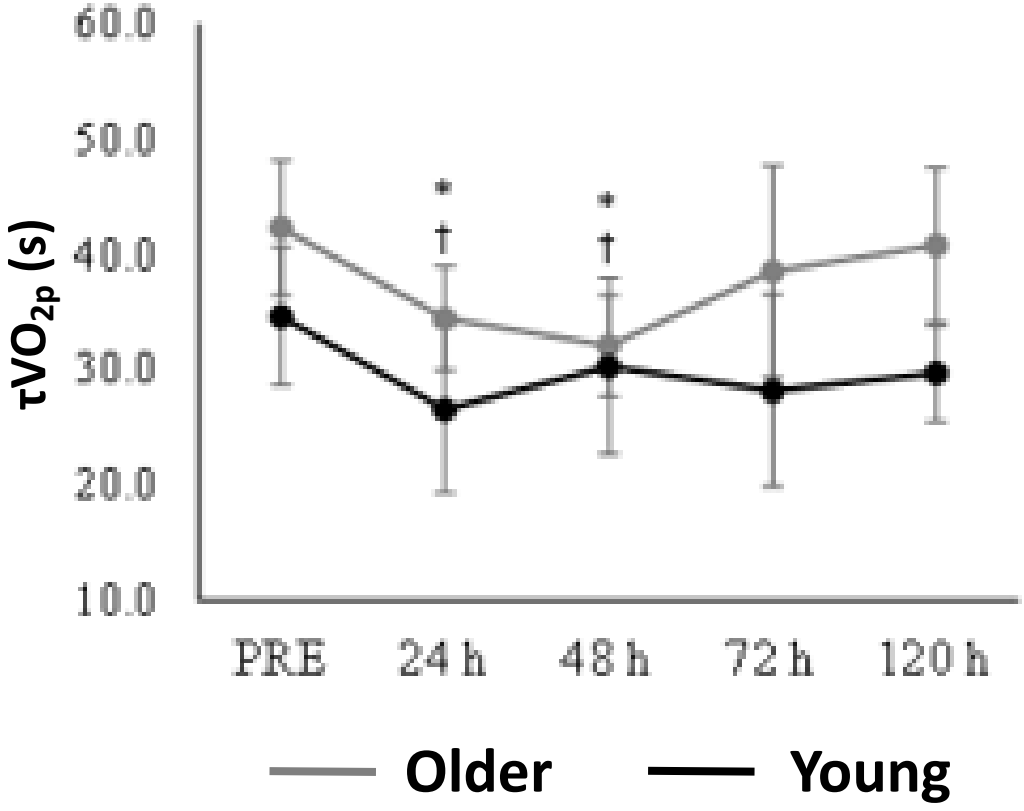
George et al., Front Physiol, 2018

How quickly can we observe the benefits of exercise training on the VO_2 kinetics response?

Effects of short-term endurance training and detraining on VO_2 kinetics and vascular responsiveness



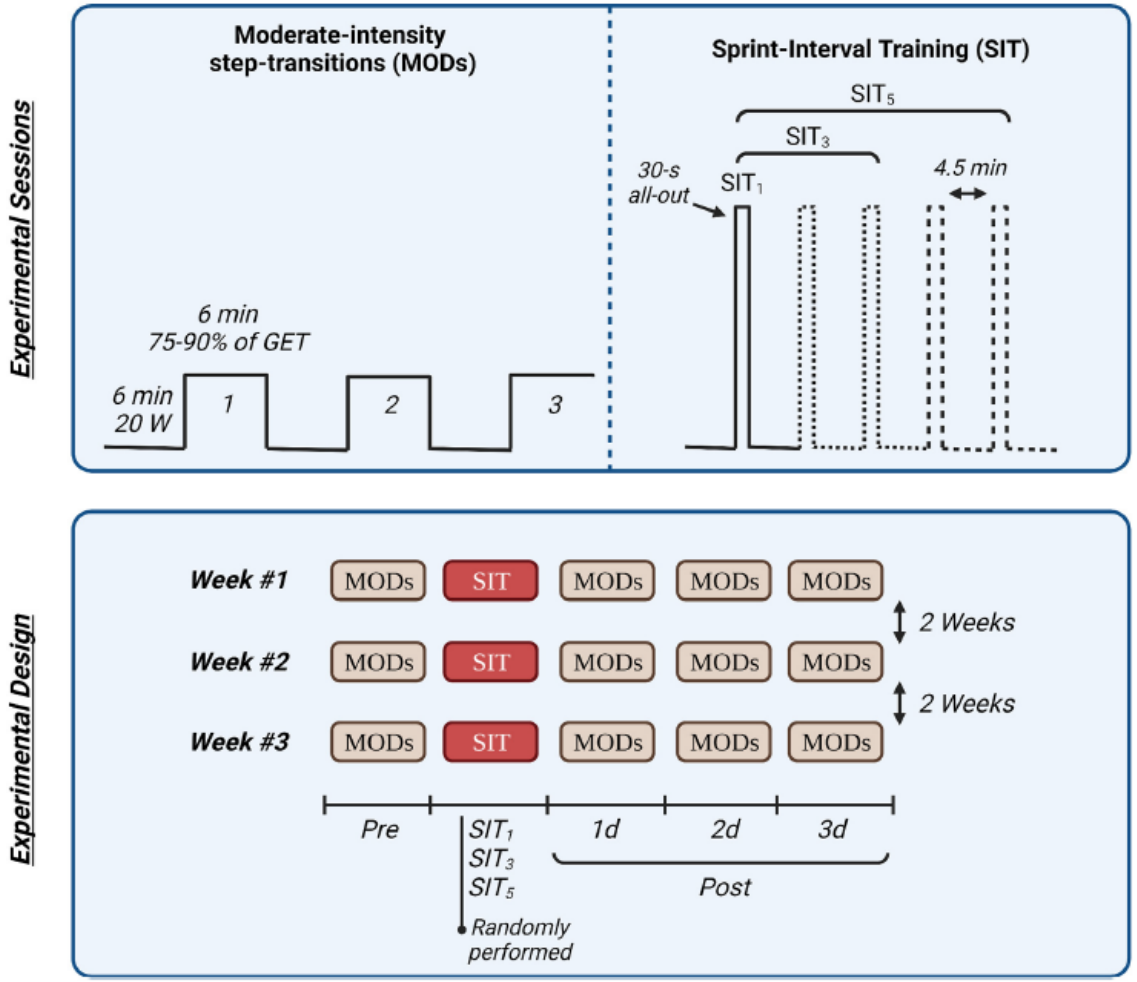
Effects of short-term endurance training and detraining on VO_2 kinetics and vascular responsiveness



[HHb]/VO_2 ratio ↓ and % FMD ↑

McLay et al., Am J Physiol 2017

Effects of a single session sprint training on VO_2 kinetics and vascular responsiveness



Iannetta et al., Exp Gerontol, 2022

Effects of a single session sprint training on VO_2 kinetics and vascular responsiveness

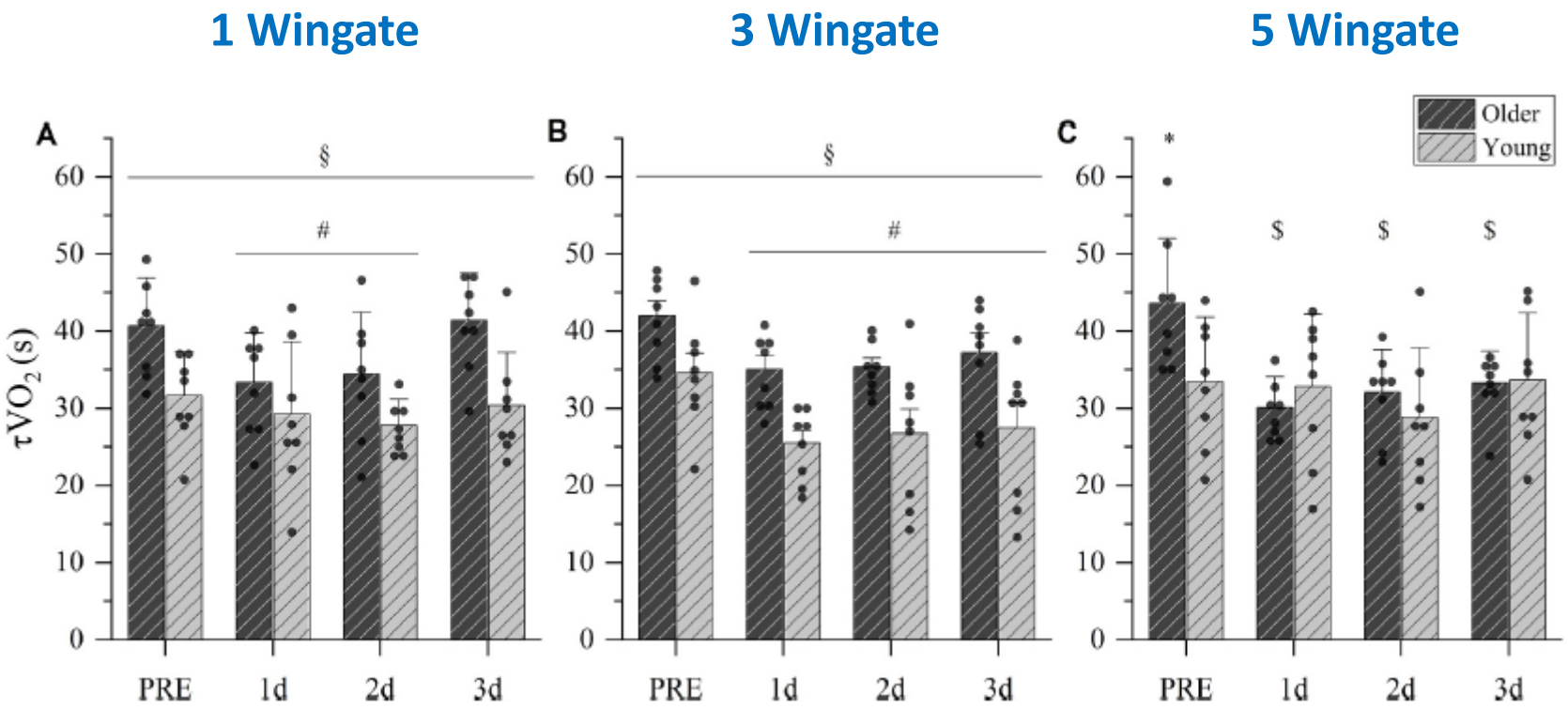


Fig. 3. Group mean and individual data of the time course of responses before (PRE) and 1 day (1d), 2 days (2d) and 3 days (3d) after completion of SIT_1 (A), SIT_3 (B), and SIT_5 (C) for τVO_2 (s). §Different from young (main effect of age; $P < 0.01$). #Different from PRE (main effect of time; $P < 0.05$). *Different from young (age by time interaction; $P < 0.05$); $Different compared to PRE (age by time interaction; $P < 0.05$).

Iannetta et al., Exp Gerontol, 2022

Some general conclusions

- Exercise training results in positive cardiovascular adaptations in the elderly that are proportional to those of young adults.
- Chronic exercise training results in adaptations that virtually abolish some of the “detrimental” effects of aging.
- Older adults positively respond to even very short training interventions.

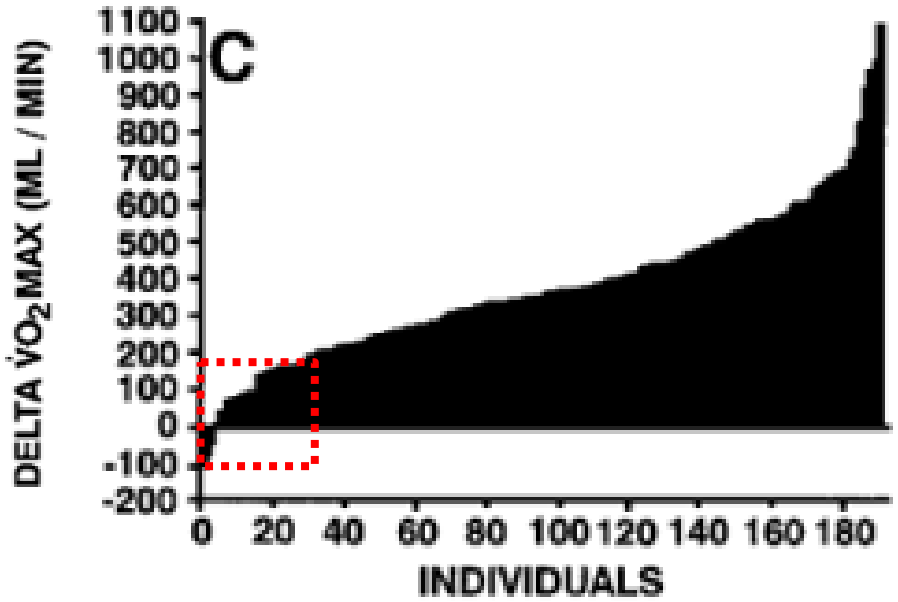
Endurance exercise training improves the overall function of the cardiovascular system

Can everyone benefit from endurance training?
What intensity of exercise is needed to improve?

Responders and non-responders to aerobic exercise

Participants: 481 individuals from 98 two-generation families of Caucasian descent (236 men, 245 women)

Training: HR associated with 55% of their initial VO_{2max} for 30 min/day and gradually progressed to the HR associated with 75% of their initial VO_{2max} for 50 min/day at the end of 14 wk.



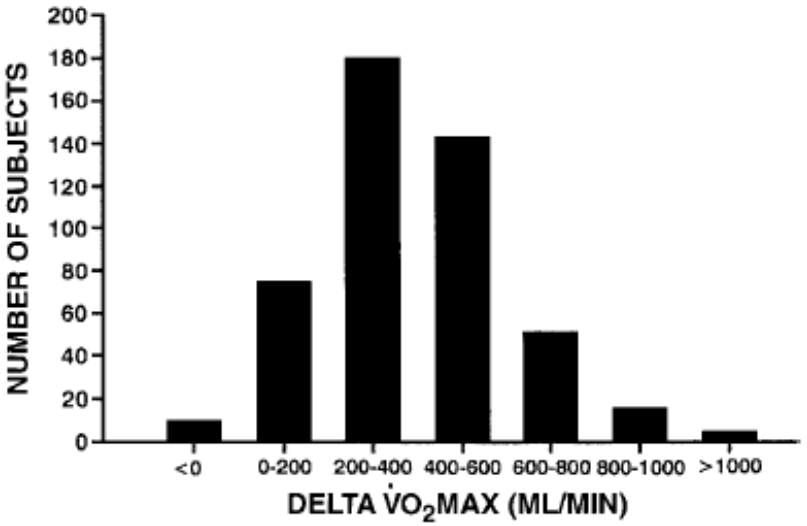
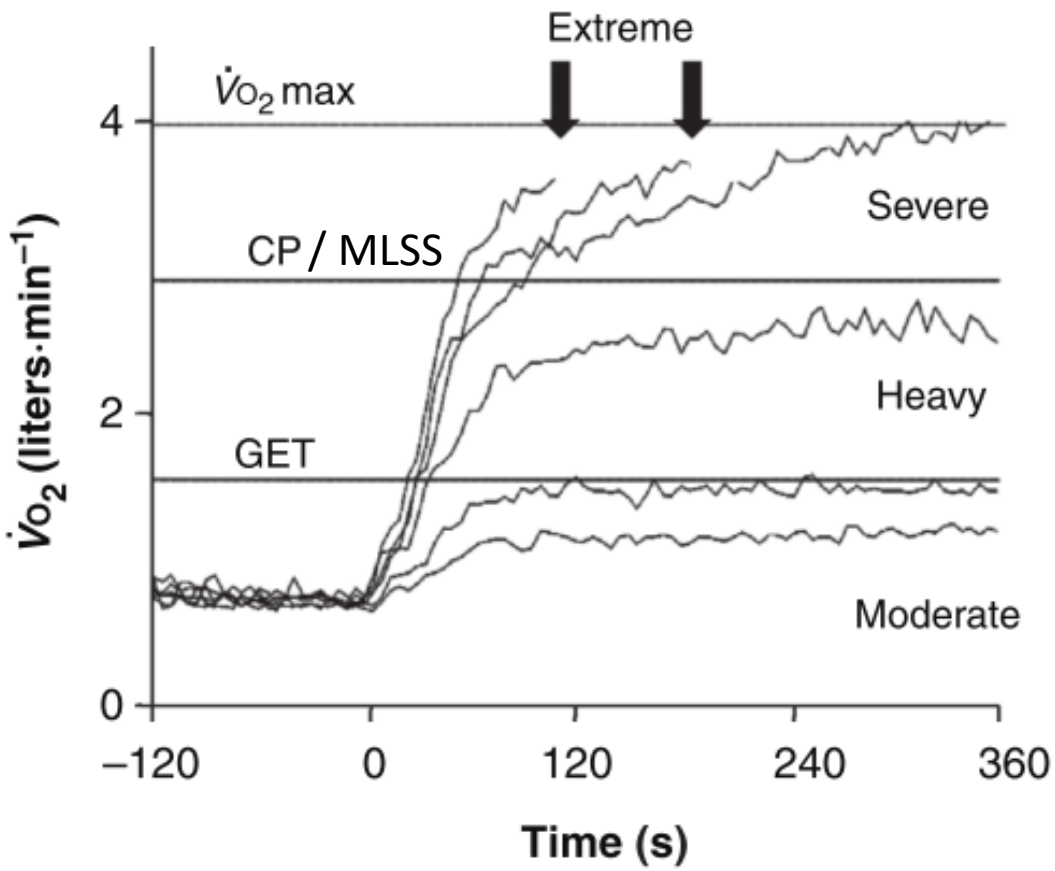


Fig. 2. Distribution of the 481 subjects by classes of increase (delta) in $\dot{V}O_{2max}$ from baseline levels.

"What is the main cause of the heterogeneity in the response to training? We believe that it has to do with as yet undetermined genetic characteristics."

Bouchard et al., J Appl Physiol 87(3): 1003–8, 1999

How do we prescribe exercise intensity? The domains model



Severe: [La] and VO_2 are unstable and project to maximal values (*ABOVE CP/MLSS*)

Heavy: increased but stable [La] and VO_2. Development of VO_{2SC} (*ABOVE GET BUT BELOW CP/MLSS*)

Moderate: no increase in [La] and stable VO_2 (*BELOW GET*)

Poole and Jones, Comp Physiol, 2(2): 933-96, 2012 (Adapted)

Exercise intensity domains: Can we get it right?

CSEP classification of aerobic exercise relative intensity based on $\dot{V}O_{2max}$ test

	$\%\dot{V}O_{2R}$ or $\%HR_R$	$\%\dot{V}O_{2max}$	$\%HR_{max}$
Very Light	< 20	< 25	< 35
Light	20-39	25-44	35-54
Moderate	40-59	45-59	55-69
Vigorous / Heavy	60-84	60-84	70-89
Very Heavy	≥ 85	≥ 85	≥ 90
Maximal	100	100	100

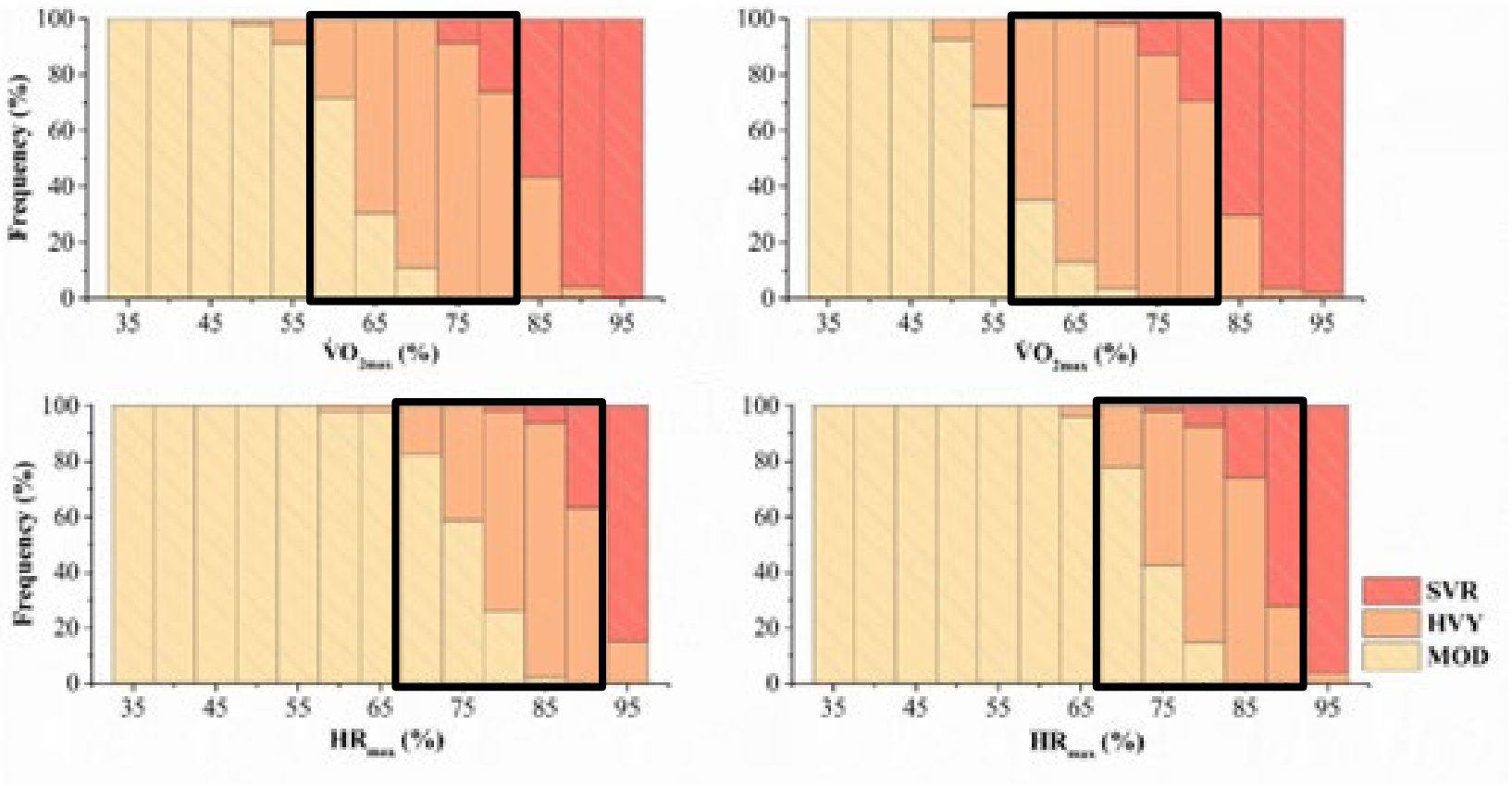
Modified from CSEP guidelines

CSEP | SCPE

Exercise intensity domains: Can we get it right?

	$\%\dot{V}O_{2R}$ or $\%HR_R$	$\%\dot{V}O_{2max}$	$\%HR_{max}$	
Heavy	60-84	60-84	70-89	**HEAVY**

Females **Males**



The most **commonly used percent values** for exercise prescription are likely to **fall within at least two** different **domains**.

Iannetta et al., Med Sci Sports Exerc, 52(2):466-473, 2020

Why should we care about the domain within which we are exercising?

Adaptations to training: is the intensity domain relevant?

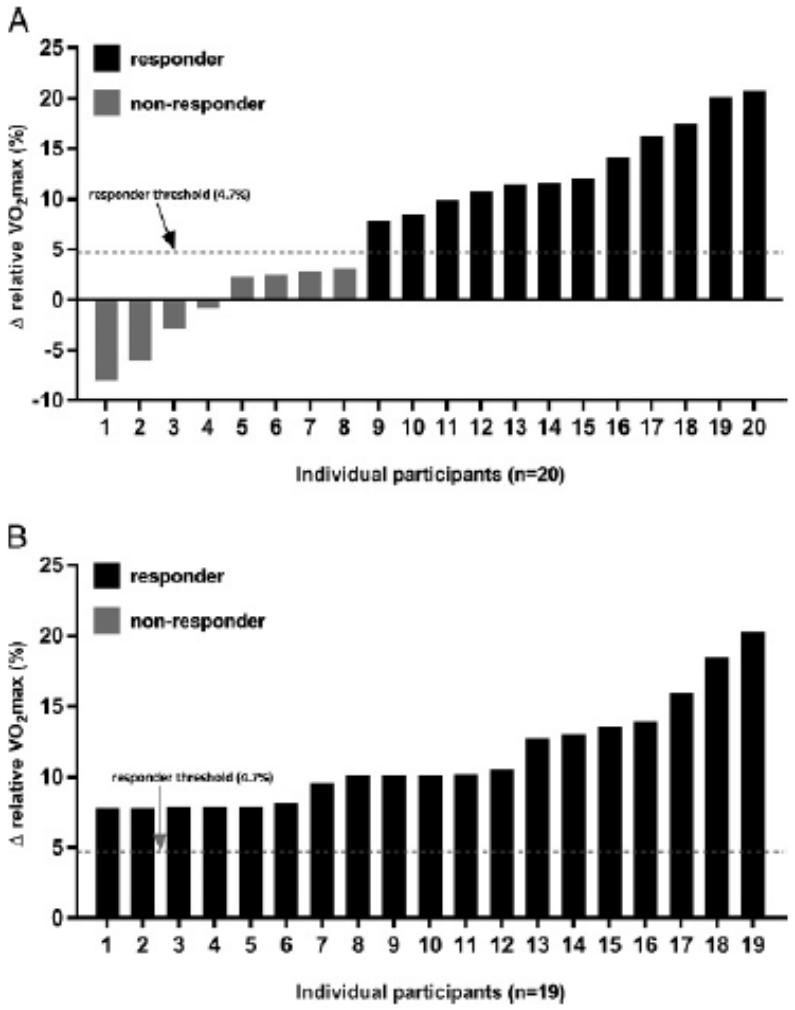


FIGURE 2—Variability in relative $\dot{V}O_2max$ responsiveness (% change) to 12 wk of standardized (A) and individualized (B) exercise training. The dashed line indicates the minimum change (Δ > 4.7%) required to be considered a meaningful adaptation in $\dot{V}O_2max$ ($mL \cdot kg^{-1} \cdot min^{-1}$).

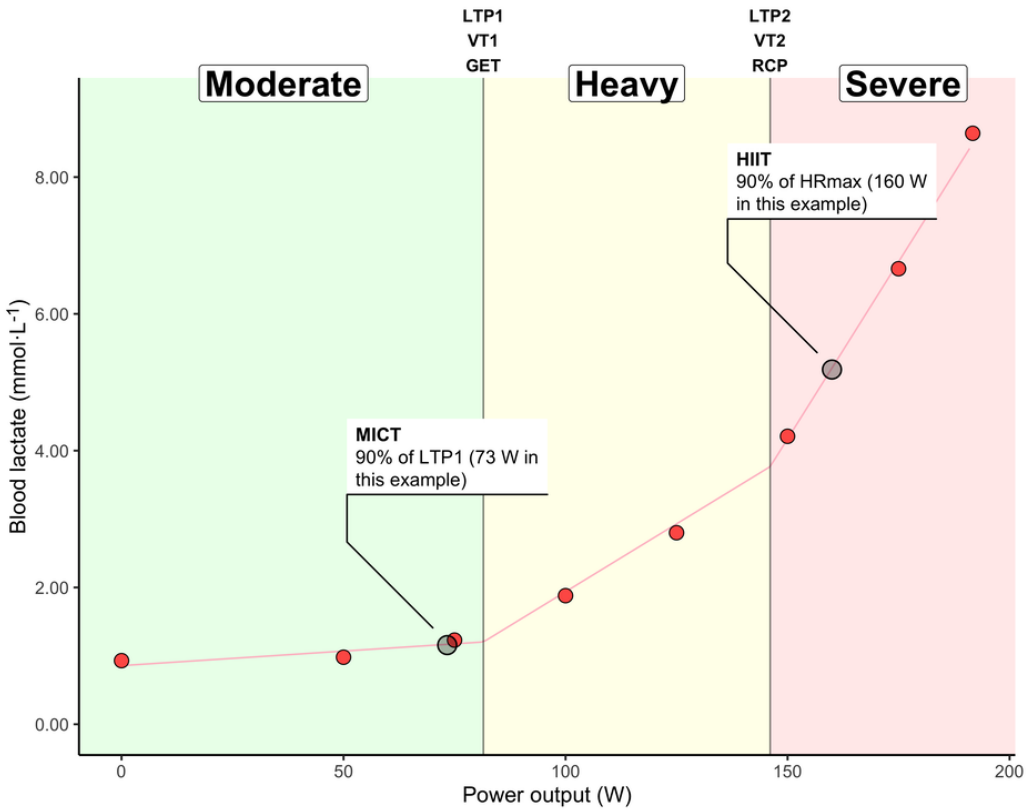
For the **standardized group**, exercise intensity was based on percentages of HRR (from **40% progressing to 65% HRR**).

The **individualized group** had an intensity that was established **based on VT1 and VT2**:

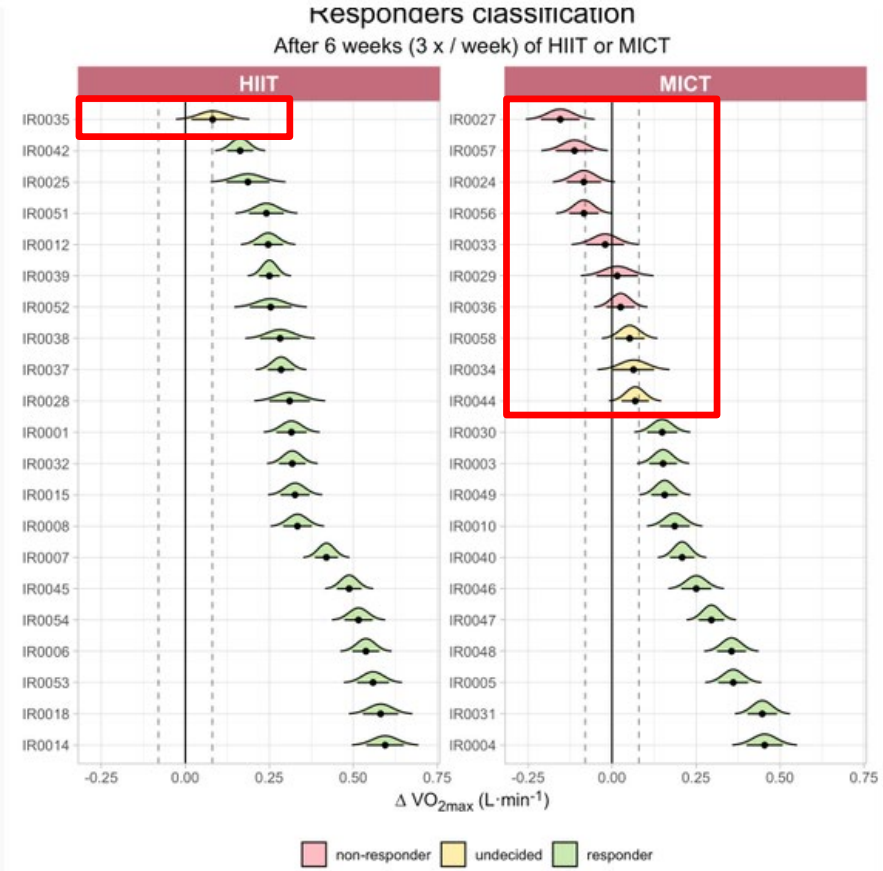
- **Target HR < VT1** = HR range of 10 bpm below VT1 to the HR at VT1
- **Target HR > VT1 to < VT2** = HR range of 15 bpm directly between VT1 and VT2
- **Target HR > VT2** = HR range of 10 bpm above VT2

Weatherwax et al., Med Sci Sports Exerc 51(4): 681–91, 2019

Adaptations to training: is the intensity domain relevant?



Mattioni Maturana et al. (under review; J Physiol)



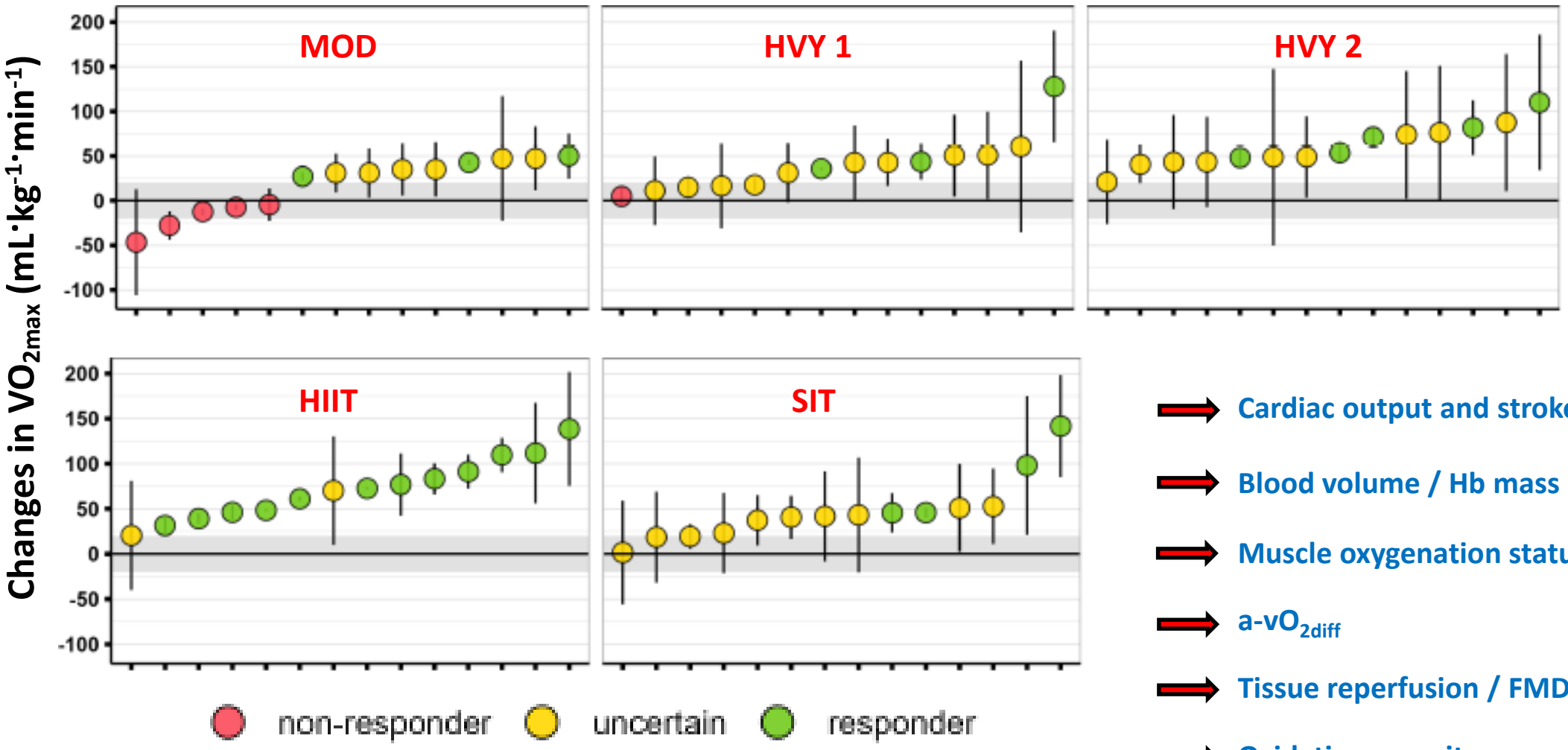
ROPE + HDI decision-making

applied to responder analysis

% of HDI in ROPE	ROPE + HDI levels of significance	Responders levels of significance
> 99%	negligible (accept null hypothesis)	non-responder
> 97.5%	probably negligible	probably non-responder
<= 97.5% & >= 2.5%	undecided significance	undecided
< 2%	probably significant	probably responder
< 1%	significant (reject null hypothesis)	responder

Adaptations to training: is the intensity domain relevant?

(MEGA Study)



- Cardiac output and stroke volume
- Blood volume / Hb mass
- Muscle oxygenation status
- $a\text{-}vO_{2diff}$
- Tissue reperfusion / FMD
- Oxidative capacity

Future studies

Endurance exercise training and aging

- **MEGA in Older adults**
  - Is “moderate” intensity exercise good for older adults?
  - Can we establish the mechanisms underlying sex-related differences?
- **Endurance exercise training in the “oldest” older participants**
  - Can we successfully intervene in octogenarians?
- **Endurance exercise training prescription**
  - Can we make it simpler?
  - Can we balance CV benefits with other potential benefits?

Acknowledgments

- Colleagues
- Students
- Collaborators
- Participants in our studies

Heart&Stroke™

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